Technologies To Improve The Detection Of High-Emitting Vehicles In A Vehicle Inspection Program

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Table of Contents

List of Figures and Tables

I. INTRODUCTION

In accordance with Health and Safety Code Section 44023(a) (Senate Bill 290-Presley, 1991), the Air Resources Board (ARB), in cooperation with the Department of Consumer Affairs, is required to report to the State Legislature on all technologies which could improve the detection of high-emitting vehicles through the vehicle Inspection and Maintenance (I/M), or "Smog Check" Program. This report is written in compliance with this mandate.

The technologies evaluated by the ARB include the use of Remote Sensing Devices and On-Board Diagnostic Systems. This report will describe each of these technologies and discuss their possible applications, strengths and weaknesses.

II. BACKGROUND

Several recent studies have pointed out that a small percentage of vehicles contribute disproportionately to the total vehicle emissions inventory. A report entitled "On-Road CO Remote Sensing in the Los Angeles Basin" (Stedman et al., 1991) claimed that ten percent of the on-road vehicle fleet is accountable for over fifty percent of the total carbon monoxide (CO) emissions inventory. Although ARB believes that this percentage may be overstated, it is well that these vehicles, categorized as "high-emitting", have exhaust emissions far greater than the standards to which they were certified.

An efficient I/M program should detect and correct high emitting vehicles to their correctly functioning state. However, the current I/M program has reduced effectiveness for several reasons, one of which is the alleged inability of the idle mode tailpipe test procedure to identify the majority of vehicles in need of repair. According to a March, 1991 publication by the U.S. Environmental Protection Agency (USEPA) entitled "Inspection And Maintenance Policy Issues", it has been shown that the present idle test procedures have become less effective at identifying high-emitting 1983 and newer model year vehicles which utilize computer-controlled closed-looped feed back systems and fuel injection.

It is also perceived by many, including the USEPA, that ineffective or incomplete vehicle repairs reduce the effectiveness of I/M programs. Many vehicles failing the program are repaired only to the degree necessary to pass the idle mode emission standards. Repairs which would reduce excessive emissions during operating modes other than idle are often not made.

Another perceived downside of the present I/M program is that all vehicles must be tested in order to identify those vehicles which are high-emitting. This practice is costly when it is considered that most vehicles pass the Smog Check inspection.

Other reasons believed to reduce I/M effectiveness involve poor mechanic performance for inspection and/or repair, readjustment of the vehicle's emission control system by mechanics or motorists after a Smog Check, and limitations imposed by low repair cost limits. Although California has the most comprehensive visual and functional tampering checks required in any I/M program, the accuracy of these checks relies on the integrity and competence of mechanics within the decentralized I/M program. In an evaluation of the current program, it was found that about 30 percent of a fleet of 900 vehicles which should have failed the Smog Check inspection were incorrectly passed. An even greater number of vehicles would have been incorrectly passed had their emissions been lower.

For these reasons, the state is evaluating and developing major improvements to Smog Check which will address each of the weaknesses of the current program. These changes will have to be implemented within two to three years in order to meet the requirements for enhanced inspection and maintenance programs contained in the Federal Clean Air Act (FCAA). As part of this effort, it is desirable to develop reliable and cost effective technologies and methods which can efficiently identify those vehicles with a high likelihood of having emission control component failures, poor maintenance, or tampering.

The in-depth discussion of all of the topics raised here is beyond the scope of this report. However, each of the following issues - test effectiveness, mechanic performance, and high emitter detection and repair - will be addressed in the context of available technologies for identifying high-emitting vehicles.

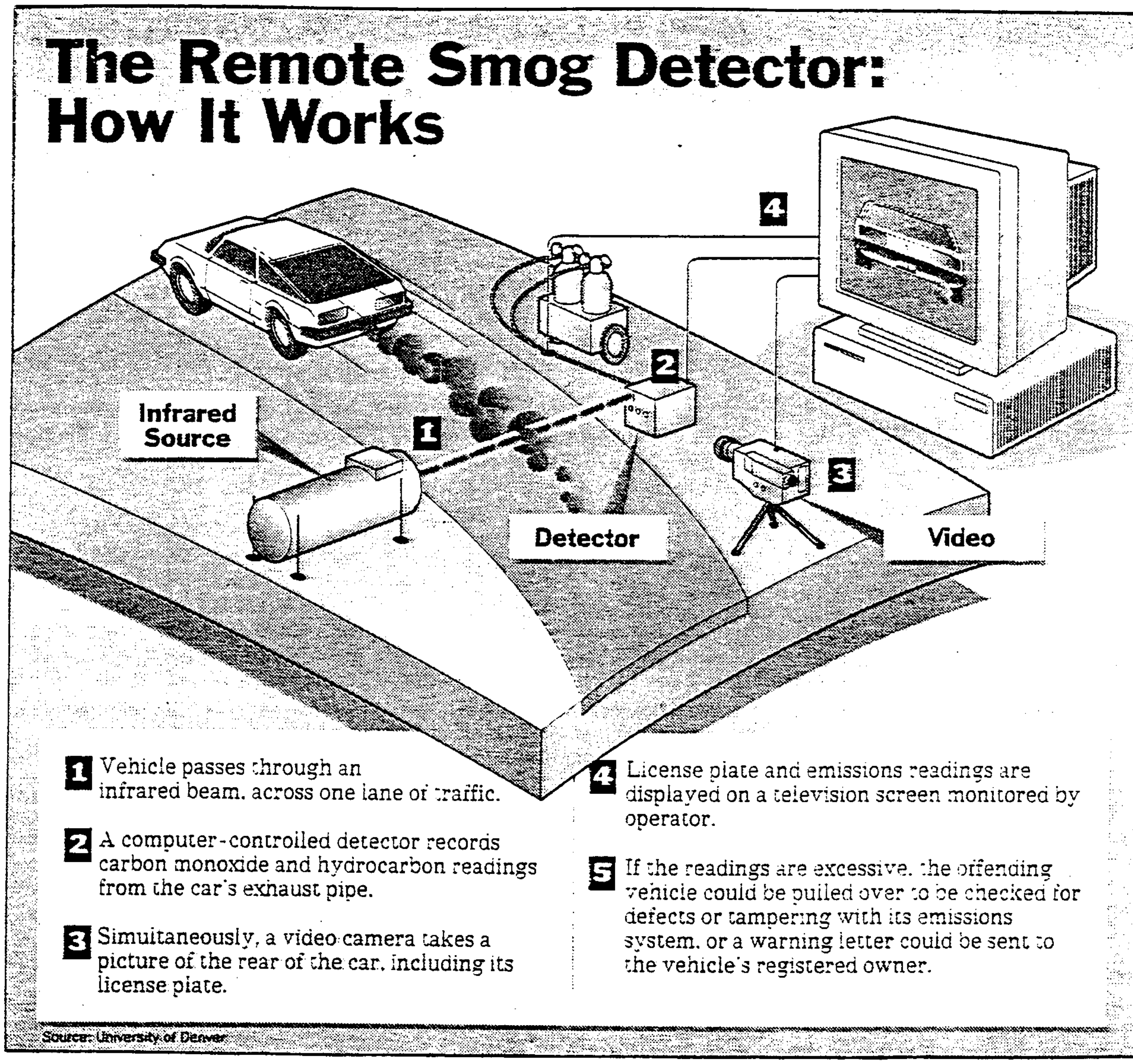
III. ANALYSIS OF THE TECHNOLOGIES

Ideally, any system intended to detect high-emitting vehicles should be cost-effective, cause the least amount of consumer inconvenience, be highly efficient in detecting malfunctioning vehicles while not failing correctly functioning vehicles, and provide the repair industry with as much information as possible for correction of the malfunction. Although no one system has all the attributes listed above, two options are currently available which have some of the desired functions of an ideal system. These systems are described below.

A. REMOTE SENSING DEVICE (RSD)

1. Description of System One proposed method for detecting high-emitting vehicles is by the use of remote sensing devices which measure the exhaust emissions of on-road vehicles. Remote sensing involves the use of a computer controlled device that transmits an infrared beam across a single lane of traffic to a receiving unit (See Figure 1). As a vehicle crosses this beam, the instantaneous concentrations of CO, hydrocarbons (HC), and carbon dioxide (CO2) are determined from the exhaust plume and recorded into computer memory. A video camera is used to record the vehicle's license plate number for later identification.

Figure 1. The Remote Sensing System



Los Angeles Times April 6, 1992

The latest innovations in remote sensing technology involve the development of an oxides of nitrogen (NOx) channel and the packaging of the detector and video equipment in a self contained van. Prototype systems also contain optical character recognition software which can digitize license plate information allowing it to be stored alongside the emissions readings in a single computer file.

2. Applications of RSD Remote sensing systems are ideally suited for detection of high emitting vehicles. It is estimated that about 1000 vehicles per hour and over 8000 vehicles per day may be monitored by the system at a very low per test cost. When positioned in selected traffic lanes, the system provides information on the number of high emitting vehicles that transverse the beam. After recording readings of emissions and corresponding license plates, the information gathered by the device could be used to assess the occurrence of high emitting vehicles in the fleet and also may be used as a means of identifying individual vehicles that could be repaired or corrected to reduce excess emissions.

It is important to note that remote sensing, as an independent system, cannot detect tampered vehicles directly. Instead, suspect vehicles are identified by their high emissions, and tampering is then verified through physical inspection. Owners of those vehicles who have intentionally tampered with their emission control systems may be fined and required to provide proof of correction of the tampering. Those vehicles which are determined not to be tampered, but have high emissions, may be referred to referee stations for more rigorous analysis and if appropriate, subsequent repair. Older vehicles identified as high emitters which are of little value or can not be repaired may be candidates for a buy-back program.

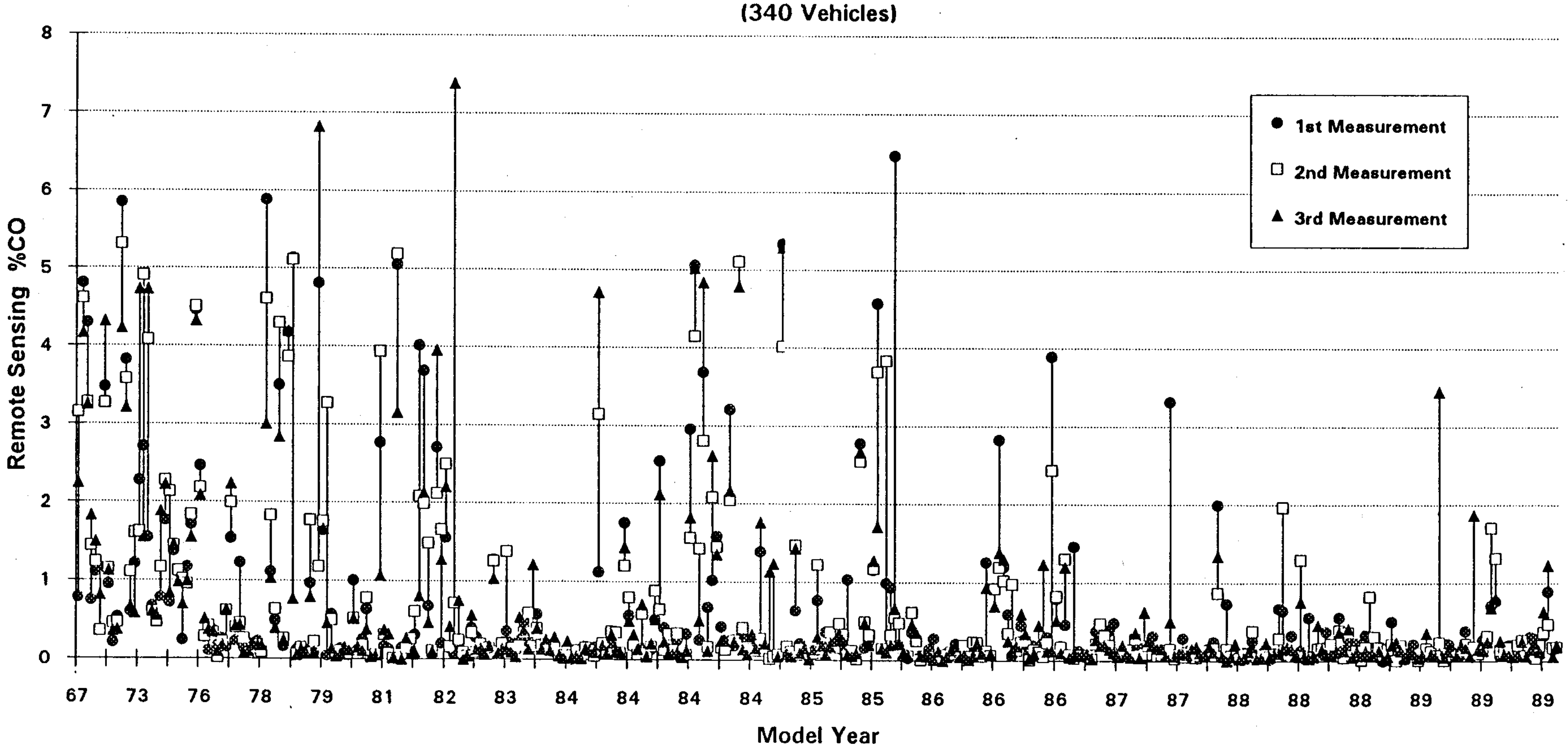
In using remote sensing to identify tampered vehicles, the advantages of a high throughput and a low per test cost may be compromised by the need to immediately physically inspect those vehicles. This is because the identification and subsequent notification of a vehicle owner based on videotaped license plate information alone may take weeks, and those conditions causing the high emissions may no longer exist when the vehicle is finally inspected.

3. Technical Assessment of RSD The staff of the Air Resources Board have been conducting on-going analyses of remote sensing technology to determine how it may best be used to improve the state's motor vehicle emission control efforts. A description of these analyses are presented below.

In the spring of 1992, 431 vehicles were tested by the ARB to examine the repeatability of measurements by remote sensing. Each vehicle was driven across the remote sensing beam three times at a uniform speed of 20 miles per hour on a level road. The variability in the repeated measurements of CO, for a subset of 340 vehicles, is shown in Figure 2. As can be seen, the remote sensing readings of several of the vehicles tested varied widely even under these tightly controlled conditions. This points out a limitation of using the results of remote sensing measurements to impose penalties or remedial action on individual vehicles because of the uncertainty of whether the vehicle is truly high-emitting.

Figure 2. Variability of Repeated Measurements by Remote Sensing

(340 Vehicles)



This same group of 340 vehicles, which were obtained from the ARB's In-use Surveillance and I/M evaluation programs, were tested to determine if a correspondence exists between high-emitting vehicles tested by remote sensing and the standard Federal Test Procedure (FTP) which is used to certify new vehicles. It was found that vehicles having high remote sensing values also tended to have high FTP values for CO.

The remote sensing measurements were conducted on fully warmed up vehicles which were driven across the beam at a uniform speed of 20 miles per hour. From this data, a cutpoint analysis was performed to evaluate the ability of the remote sensing device to properly identify vehicles which display high emissions over a predetermined FTP gram per mile limit. It is important to note that this analysis would represent a best case correlation since several parameters were controlled which could not be controlled in an actual on-road application. Figure 3 shows the results of this analysis. At this time, not enough vehicles have been tested to show a conclusive statistical relationship between the remote sensing and FTP measurements.

Several scenarios can be explored based on the data in Figure 3. For example, if a remote sensing limit of 3 percent tailpipe CO was used to identify vehicles with FTP emissions exceeding 60 grams per mile (a level that would be considered high-emitting), 23 vehicles would be identified as high emitters by remote sensing. Of these 23 vehicles, 7 vehicles would be incorrectly identified (or falsely failed).

Essentially, Figure 3 can be divided into four quadrants to show how remote sensing data can be used to identify high-emitting vehicles. The vehicles correctly identified as high emitters are shown in quadrant A. Quadrant B shows the number of undetected high-emitting vehicles, or the errors of omission. Quadrant C contains the vehicles correctly identified as passing the FTP and remote sensing criteria. Finally, quadrant D contains those vehicles which may be falsely failed, or the errors of commission.

Table I shows the possible errors of commission and omission that may result for selected remote sensing percent CO cutpoints assuming 60 grams per mile on the FTP as the definition of a high emitter. For example, at the 3 percent cutpoint, 7 vehicles (2.05%) would be incorrectly identified as high emitters (errors of commission), 16 (4.68%) of the vehicles which are actually high-emitting would be incorrectly identified as clean (errors of omission), and 16 (4.68%) of the vehicles would be correctly identified as high emitters. The remaining vehicles would pass both FTP and remote sensing criteria. At a numerically higher remote sensing cutpoint of 5 percent, there are no incorrect failures, however the number of high-emitters identified would drop by more than one half, and the number of high emitters not identified by the remote sensor would increase to about four times the number correctly failed.

Figure 3. The Comparison of Remote Sensing Measurements to FTP

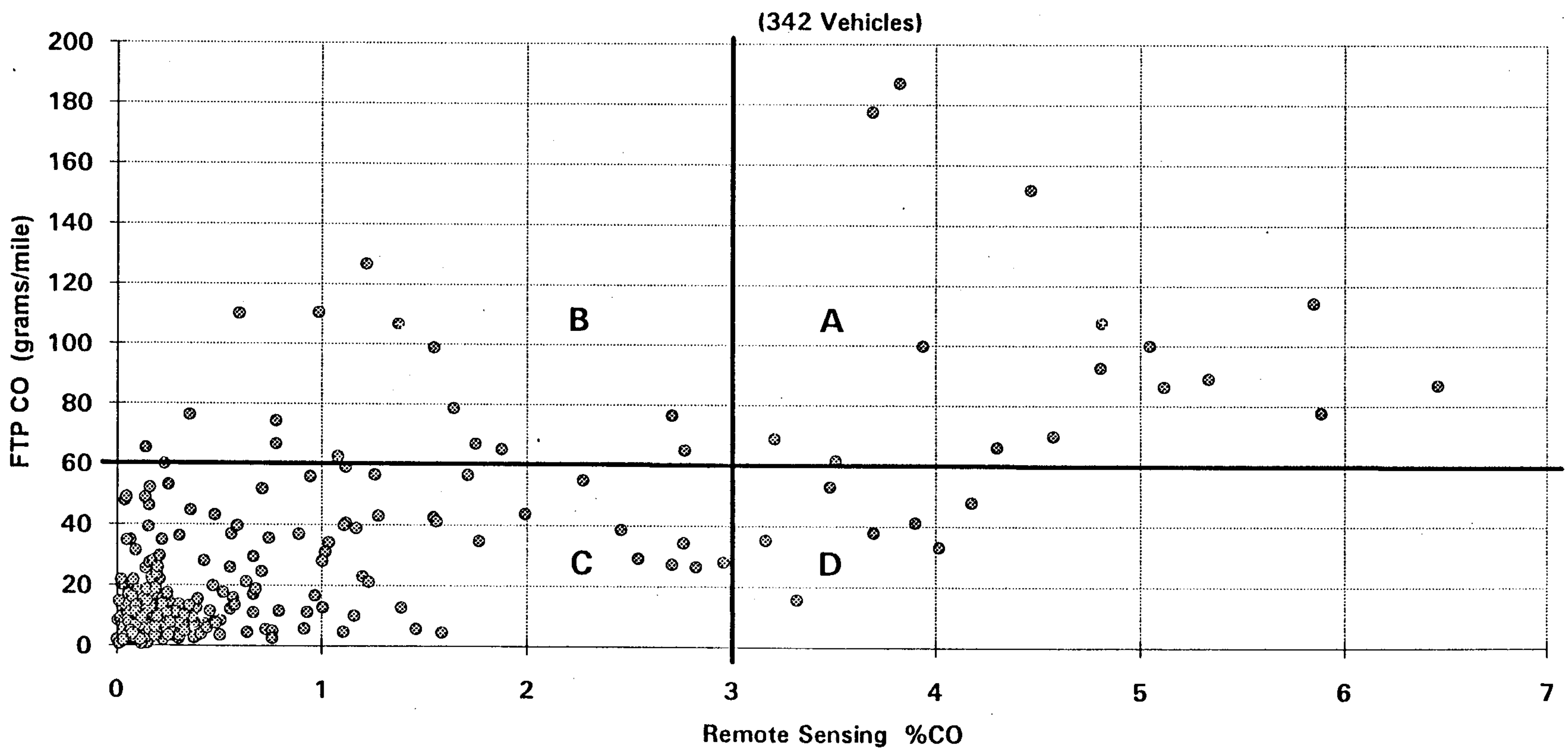


Table I. Cutpoint Analysis of Figure 3

Remote Sensing vs FTP Carbon Monoxide Measurements

Remote Sensing Cutpoint	Errors of Commission	Errors of Omission	Correctly Failed	Correctly Passed
1 %	10.53 %	2.05 %	7.31 %	80.12 %
2	4.09	4.09	5.26	86.55
3	2.05	4.68	4.68	88.60
4	0.58	6.14	3.22	90.06
5	0.00	7.60	1.75	90.64
6	0.00	9.06	0.29	90.64

Note: The above table defines a vehicle with FTP emissions above 60 grams per mile as a high emitter.

Although Table I indicates that remote sensing is correct approximately 90 percent of the time, in actual use the remaining errors of commission may result in thousands of vehicles being falsely failed. To minimize these false failures, the ARB investigated the feasibility of using two remote sensing measurements to better identify high emitters. For this application, only the vehicles failing the cutpoint on each of two remote sensors would be identified as high-emitting and recommended for subsequent inspection and/or repair. In analyzing this assumption, one remote sensing device was used and replicate readings of 334 vehicles and their corresponding FTP CO emissions data were analyzed. The results of this analysis are shown in Figure 4.

The variability, resulting from two remote sensing measurements per vehicle, as shown in Figure 4, is a major concern when selecting a cutpoint that would minimize the errors of commission and omission. By using Figure 4, Table II can be constructed to show the various remote sensing cutpoints and the associated errors of commission and omission, as well as the number of vehicles which should be correctly identified as high emitters using two remote sensing measurements.

Table II. Cutpoint Analysis of Figure 4

Vehicles Having Two Remote Sensing Measurements

Remote Sensing Cutpoint	Errors of Commission	Errors of Omission	Correctly Failed	Correctly Passed
1 %	7.19 %	2.40 %	6.59 %	83.83 %
2	2.10	4.19	4.79	88.92
3	0.60	5.39	3.59	90.42
4	0.00	7.19	1.80	91.02
5	0.00	8.08	0.90	91.02
6	0.00	11.13	0.00	91.02

Note: The above table defines a vehicle with FTP emissions above 60 grams per mile as a high emitter.

Figure 4. Variability of Two Remote Sensing Measurements vs FTP

(334 Vehicles)

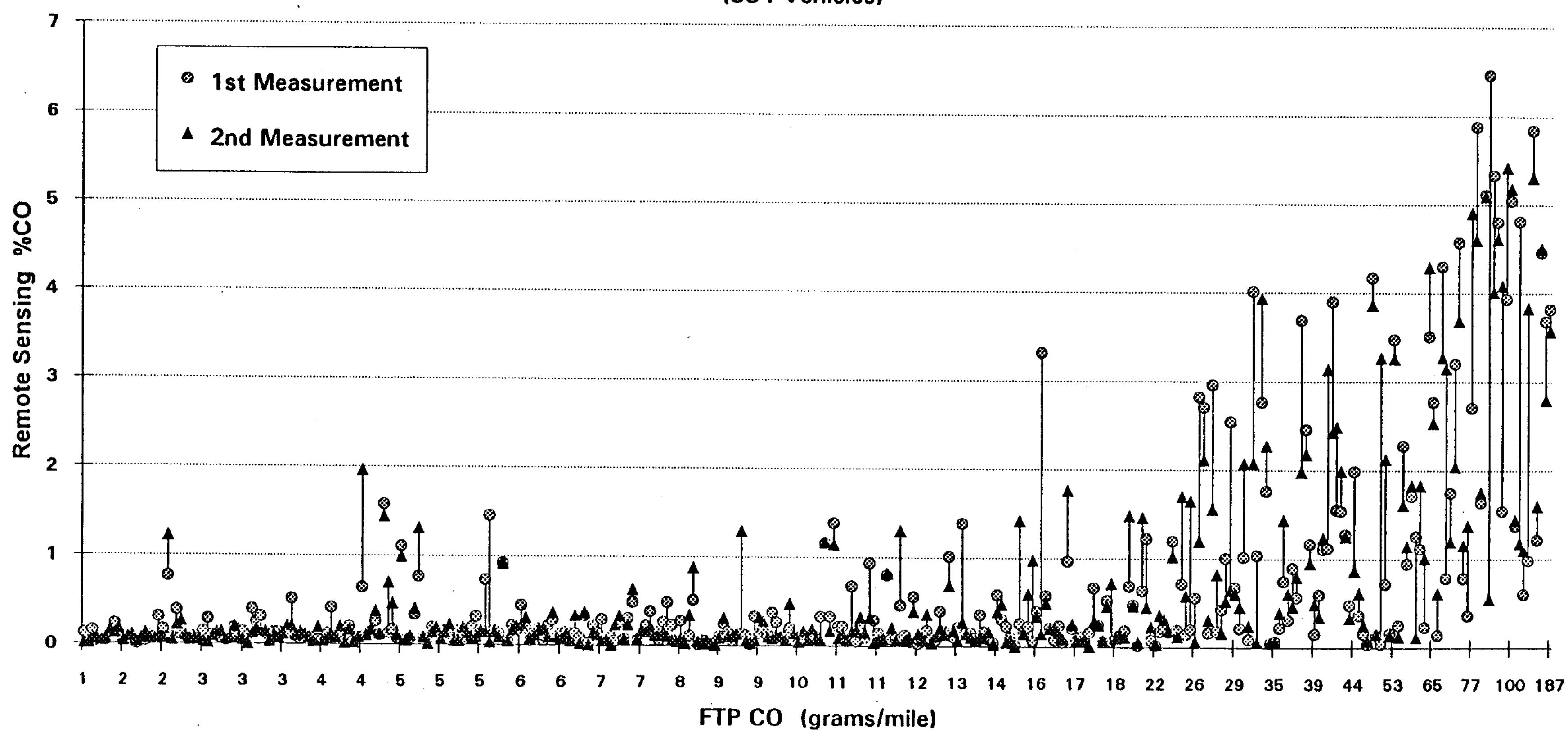


Figure 4a magnifies the high end of Figure 4 showing thirty vehicles having FTP CO measurements above 60 grams per mile. For example, it can be noted from Table II that there are no errors of commission at the 4 percent remote sensing cutpoint. However, when using 4 percent as the cutpoint in Figure 4a, 24 of the 30 highest emitting vehicles would not fail twice and would not be recommended for later inspection, thus increasing the errors of omission.

By comparing Table II to Table I, the differences in using two remote sensing measurements instead of a single measurement to identify a vehicle can be observed. By using a second measurement, the errors of commission are seen to decrease while the errors of omission increase at each cutpoint. It should be noted that equipment variability is not considered in this analysis since the second measurement for this dataset was made by the same device. In establishing pass/fail cutpoint criteria for I/M applications, the use of two remote sensing devices would lower the number of falsely failed vehicles and minimize inconvenience to motorists.

To provide an example of actual in-use results of using remote sensing, an analysis was performed of a ten-day study conducted by the ARB where a single remote sensing device was used to identify vehicles having high CO emissions. A total of 60,487 vehicles were analyzed and approximately six percent (about 4,000 vehicles) were considered to be high emitters with readings exceeding the five percent CO cutpoint (no analysis of the errors of omission and commission was performed). It was found that two inspection teams were able to physically inspect about 30 high-emitting vehicles a day. A total of 307 of the vehicles identified by remote sensing as high-emitting were immediately given a roadside inspection equivalent to the Smog Check, of which, 282 (92%) failed. However, only 41 percent of the 307 inspected vehicles were determined to have tampered emission controls.

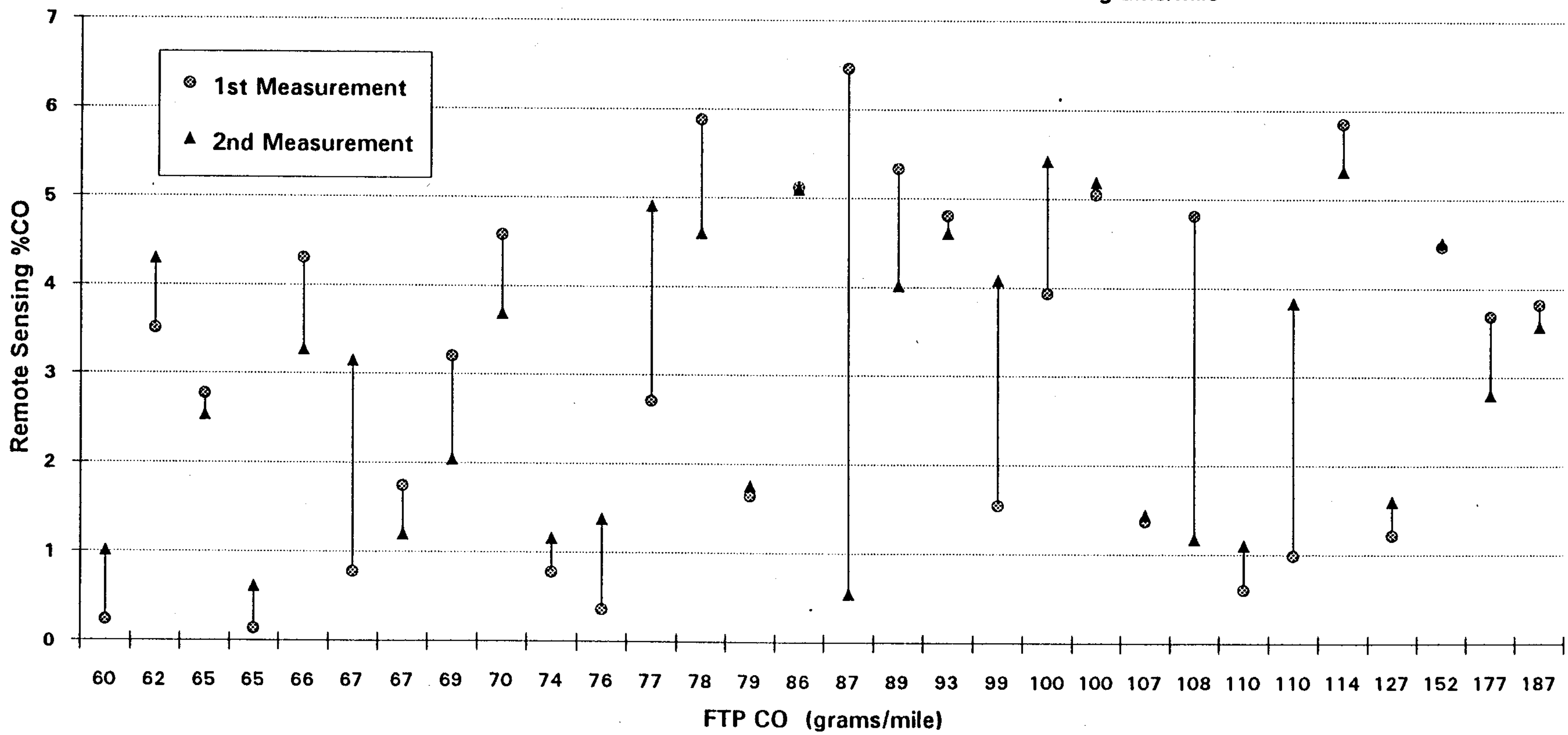
4. Advantages and Disadvantages of RSD There are several advantages to the use of remote sensing relative to the conventional idle test currently used in the inspection and maintenance program. The test is unobtrusive, it is not constrained to idle conditions, throughput is high, and per test costs are low.

Because the remote sensing equipment is portable, it allows testing at various sites. In addition, the test is not limited to idle, and since the vehicle to be tested need not stop during the measurement phase, the test would not inconvenience the driver.

However, to capitalize on the advantages of remote sensing as a tool for detecting high emitters, the limitations should be identified and understood. Remote sensing is effective only if the testing conditions are well controlled. Motor vehicle emission levels are sensitive to variations in speed and are greatly influenced by accelerations and decelerations. For example, an inherently low emitting car could be falsely identified as a high emitter by the remote sensor if the speed of the vehicle is not controlled while crossing the infrared beam or if the driver pressed the accelerator at that instant.

Figure 4a. Variability of Two Remote Sensing Measurements vs FTP

30 Vehicles With FTP Measurements Greater Than 60 grams/mile



The sensitivity of the remote sensing device has been studied extensively by both the ARB and the USEPA. Testing to determine the variability of CO emissions by vehicle operating mode was conducted by the ARB at the Santa Anita Race Track in May of 1991. Within this study entitled "On-Road Remote Sensing of Carbon Monoxide and Hydrocarbon Emissions During Several Vehicle Operating Conditions," (Ashbaugh, Lawson et al., 1991) remote sensing was used to measure the emission variations of twenty-three vehicles over various operating modes. The operating modes which were evaluated and their respective CO and HC emission variations are shown in Figure 5. The operating modes included a rolling idle (in gear but foot off the accelerator), steady state cruises at 5, 15, 30 and 45 miles per hour, and light, medium and hard accelerations. In addition, two identical decelerations across the infrared beam from 30 miles per hour were attempted for each vehicle.

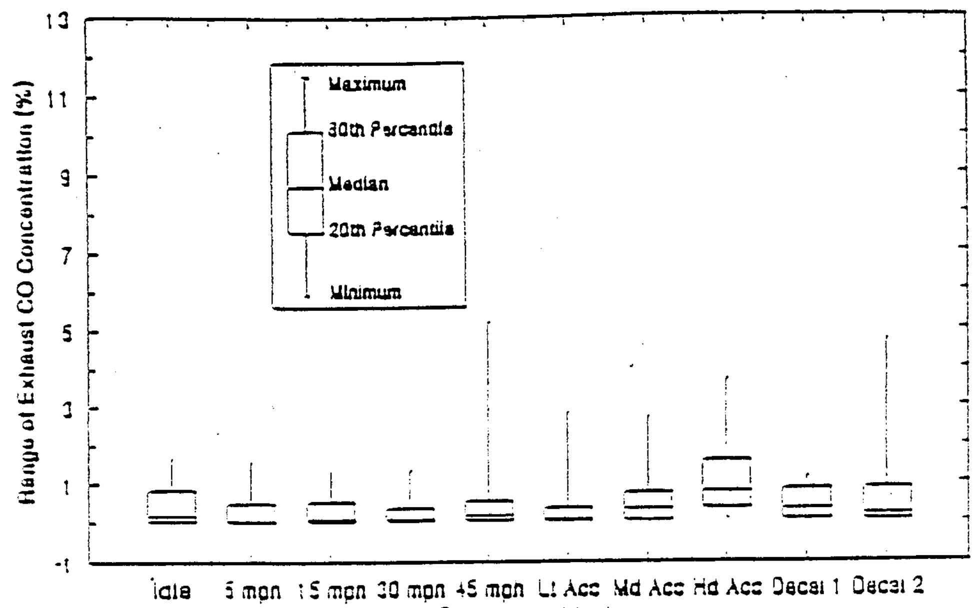
The results of the testing showed that the variability for exhaust CO was least during the cruise speeds of 15-45 miles per hour, and for light accelerations. The greatest variations of exhaust CO occur under hard acceleration. For exhaust HC, the variability was least during accelerations, but greatest during decelerations.

Automobile exhaust emissions are normally higher during cold start operation since the catalyst has not reached peak efficiency. This is especially true for emissions of CO. The remote sensing device would not be able to determine whether the vehicle is in cold start mode, leading to possible errors of commission. Falsely failing too many clean vehicles would undermine the public confidence and result in low acceptance of programs which utilize the device. As an example, from the ten-day study mentioned above, ten vehicles determined to be in cold-start mode were identified as high-emitting by remote sensing, however, all passed the roadside inspection.

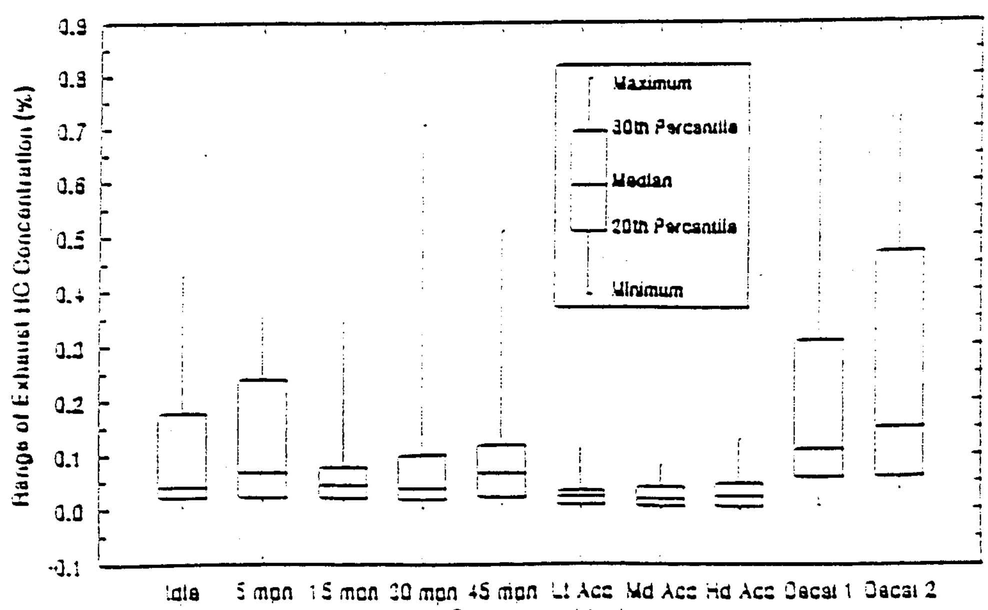
Another concern with using the remote sensing device is the limitations imposed by its physical setup. A single driving lane is required because the remote sensing device is limited to testing traffic flow in single file. Thus, multilane highways would need to be channeled down to one lane resulting in some traffic congestion and limiting the times and location of device operability. This limitation may result in traffic delays and avoidance of the test area. The road grade should also be considered in order to standardize the engine load during testing. In a report entitled "Identifying Excess Emitters with a Remote Sensing Device: A Preliminary Analysis," (Glover and Clemmens, USEPA, 1991) the effectiveness of remote sensing was evaluated with respect to uphill and level road testing. It was found that the uphill results showed a fairly high level of repeatability which may be due to smaller load variations than would be found by driving a level road.

Figure 5. Range of Emissions on Repeated Runs of 23 Vehicles According to Vehicle Operating Mode

Variability of CO Emissions by Vehicle Operating Mode
FEAT 3002 - Middle



Variability of HC Emissions by Vehicle Operating Mode
FEAT 3002 - Middle



Note: The distribution of emissions illustrated in the above charts are bounded by zero and the highest single recorded reading. The "y" axis scaling is not uniform.

Testing conducted by USEPA during light rain found that the infrared beam was interfered with due to water splashed up by the tires. Measurements performed on wet pavement resulted in an increase in the number of invalid readings. A plume interference analysis was also conducted to determine the effects on the measurement of a plume if the remnants of a previous vehicle's exhaust was still present. From this study, it was found that the remote sensing readings will be about 0.5 percentage points higher for a vehicle following another vehicle within one or two seconds which had emissions greater than 5 percent.

It must also be realized that not all exhaust plumes would pass through the infrared beam at a uniform height. This would contribute to errors of omission where vehicles with relatively high or vertical tailpipes would pass by without being tested. For the above reasons, careful site selection is critical in obtaining accurate results.

Although remote sensing may be fairly accurate, false failures (errors of commission) and physical restrictions (single lane, rain, etc.) limit its overall effectiveness. The ARB is currently testing 1000 vehicles identified by remote sensing to better quantify the accuracy of the device and determine its most practical use for identifying high-emitting vehicles.

5. Improvements to the Motor Vehicle Emissions Inventory The emissions inventory is used by the ARB and air pollution control districts to evaluate the effectiveness of emission control measures. The use of remote sensing may help improve the state's motor vehicle emissions inventory by providing information on high-emitting vehicles which contribute disproportionately to the inventory.

The advantages of using the device include those previously mentioned with respect to identifying tampered vehicles. Unlike tampering inspections where the vehicle is required to stop, the high throughput of testing per device would provide a large body of data which can be used to determine the population and model year distribution of high emitting vehicles in the on-road fleet. These data can be used to correct for biases in the more comprehensive testing performed on consumer vehicles in ARB's laboratory. A program to collect data for this purpose began in August, 1992. Remote sensing data could also be used to determine geographical differences in vehicle emissions, since laboratory testing is currently restricted to the Los Angeles area.

A limitation of using remote sensing data for improving the inventory is that it cannot be used to numerically predict actual mass emissions. Since remote sensing records instantaneous CO concentrations, it is necessary to assume an instantaneous fuel economy for the vehicle in order to estimate the mass emissions. These assumptions may lead to serious errors. For example, a large and small vehicle may have the same CO concentration readings, however, their mass emissions may differ substantially due to the differences in their fuel economies. The data from remote sensing can, however, be used to estimate the population of high-emitting vehicles in a geographic area.

6. Enhancements to the state's Smog Check Program The current Smog Check program is a decentralized biennial program that requires idle emissions tests as well as visual and functional checks. As previously mentioned, one of the major disadvantages of the current I/M program is the testing of all vehicles in order to identify and repair the small subset of high-emitting vehicles.

Remote sensing technology could be used as a screening tool, under controlled conditions, to detect high-emitting vehicles at a fast throughput for subsequent testing and repairs. In a centralized test program, the device could be used to screen out the majority of clean cars, allowing resources to be focused primarily on the high emitters which may have been tampered. Here, a fewer number of devices would be needed at a low per test cost, making this an attractive application for remote sensing.

Remote sensing, in conjunction with roadside inspections, could also be used to identify vehicles which have become high emitters between biennial smog inspections. This could help deter tampering, especially if a fine was imposed on owners of tampered vehicles, as has been proposed by some groups. Owners of cars with high emissions which have no tampering could be advised or required to obtain needed maintenance or repairs. Overall, the presence of remote sensing could increase the desire of vehicle owners to seek proper inspections, encourage better repairs, and deter tampering.

Remote sensing is not a viable option to completely replace a conventional Smog Check inspection because it would not evaluate emission control systems that have no effect on tailpipe emissions such as positive crankcase ventilation (PCV) and evaporative emission control systems. Based on California's motor vehicle emissions models, it is estimated that evaporative emissions account for almost 33 percent of the reactive organic gases (ROG) being produced by light duty passenger cars in the 1992 calendar year. Failures of these systems can only be identified by a visual and/or functional inspection. In addition, the accuracy of current remote sensing technology in measuring oxides of nitrogen (NOx) emissions is still in question. Although the current I/M program does not directly measure NOx, NOx emission reductions are achieved because visual and functional inspections of components affecting NOx emissions are performed. As previously mentioned, the inspection process is necessary to actually determine whether a vehicle was in fact, tampered, and would provide insight to the cause of high emissions.

In order to use remote sensing in a Smog Check program, appropriate pass/fail criteria would have to be developed. These criteria should be developed such that the rate of false failures is low. A cutpoint analysis similar to that of the preceding section (see Table I) would help to determine these criteria. The number of false failures may be reduced if two devices are employed (see Table II). Conditions for testing must still be controlled as previously mentioned with a single lane setup, proper beam placement, and passing speed.

B. ON-BOARD DIAGNOSTIC SYSTEMS (OBD)

1. Description of System First generation On-Board Diagnostic Systems (OBD-I) systems were phased-in beginning with 1988 model year California vehicles. These systems monitor a limited number of emission control components during normal operation. The second generation is OBD-II which will be phased-in between 1994 and 1996. The electronic control unit on-board the vehicle will monitor, at a minimum, the fuel system, oxygen sensor, exhaust gas recirculation (EGR) system flowrate, catalyst conversion efficiency, catalyst heating system, secondary air system, misfires, and evaporative control system. A malfunction indicator light will illuminate to alert the vehicle operator of any component malfunction. Generally, this light would illuminate when a failed or deteriorated component is expected to cause emissions to exceed 1.5 times the vehicle's certification exhaust standard.

All vehicles equipped with the OBD-II system will have standardized system features. These include standardized fault codes, standardized on-board to off-board communication protocol, and a standardized diagnostic connector. This standardization allows the OBD-II computer system to connect with the Smog Check computer during inspection. Here, the on-board computer would be examined to verify any fault codes. These fault codes would provide diagnostic information that would allow the mechanic to identify the failed components and effect the proper repairs.

The OBD-II system provides the means to more accurate and efficient emission control component repairs. Vehicle operators would be alerted immediately of any malfunction, allowing the opportunity for repairs before the emissions become excessive and prior to scheduled periodic inspection. The early detection of emission component malfunctions by the OBD-II system is expected to reduce the number of potential high-emitting vehicles from the on-road fleet.

2. Enhancements to the state's Smog Check Program The OBD-II program will effectively enhance the current Smog Check program in many ways. One distinct advantage of OBD-II is that it provides continuous monitoring of a vehicle's emission control components instead of relying on a periodic check performed by the current Smog Check program. Another advantage of OBD-II is that it provides fault codes which can assist mechanics in directing their repair efforts to specific components. The on-board computer will transmit its fault codes to the Smog Check computer through a standardized interface. This will greatly reduce the number of improper diagnoses and adjustments made by mechanics and thereby remedy one of the weaknesses of the current Smog Check program. In addition, the OBD-II system will be highly resistant to tampering.

A Smog Check program for high-tech OBD-II equipped vehicles might consist of a simple check of the OBD system and the malfunction indicator light. A conventional Smog Check inspection would no longer be necessary since vehicles would need repairs only when malfunctions are identified.

An experimental technology that would improve the OBD-II system is the on-board transponder. A transponder is a small transmitter which could broadcast a vehicle's identification number and any fault codes to a roadside receiving station. Thus, as vehicles traverse selected sampling sites, any malfunctions stored in the vehicles computer would be noted by the receiving station, along with the vehicle's identification number. The owners of these vehicles could be notified by a regulatory agency, increasing the probability of having those vehicles repaired quickly, and removing potential high-emitters from the in-use fleet. Without the use of transponders, motorists could ignore the OBD-II malfunction indicator lights until their next Smog Check, up to two years. The use of on-board transponders may move the concept of Smog Check into a fully automated computer-based operation. The ARB is equipping a vehicle with a transponder in order to gain some real-life experience with this concept.

IV. CONCLUSIONS

The objective of the state's Smog Check program is to correctly identify, diagnose and repair vehicles having excessive emissions. Reliable and cost effective methods of identifying these vehicles is the first step to reducing the total emissions of the on-road vehicle fleet, including the highest emitters. Changes which will improve the program's ability to meet this objective are being developed.

It is important to note that none of the proposed technologies would be effective in and of themselves in reducing the contributions of high-emitting vehicles to the overall emissions inventory. The best use of these technologies is to narrow the focus of effort towards vehicles with a high probability of failure. The need persists to further enhance the I/M program to ensure the proper diagnoses and repair of these vehicles.

Beginning with 1994 through 1996 model year vehicles, the use of the OBD-II system to monitor vehicle emission control components and identify malfunctions will reduce the number of potential high-emitting vehicles in the fleet. The OBD-II system will help improve mechanic performance, providing the means for more accurate and efficient emission control component repairs.

The OBD-II system becomes an effective identification and repair tool only if the vehicle operator acknowledges the malfunctions. An on-board transponder capable of transmitting vehicle information to roadside receiving stations would provide the means to notify regulatory agencies of those vehicles in need of repair. Although the implementation of OBD-II with transponder capabilities may one day replace today's Smog Check, some form of a vehicle inspection program would still be required for many years to diagnose and repair vehicles not equipped with this new technology.

In conjunction with roadside inspections, remote sensing may be used to identify high emitting vehicles in the existing fleet, and effect their repair. It can also be used to deter tampering with emission controls which may occur between smog inspections. Remote sensing can also provide the means of conducting unobtrusive surveys to assist in developing better emission estimates for the inventory.

The main concern with using remote sensing involves errors of omission (not detecting some high emitters), and errors of commission (failing some clean vehicles). However, it is possible to reduce the errors of commission by requiring more than one exhaust measurement per vehicle. The acceptable limits of these errors must first be determined before remote sensing can be routinely used. In addition, emissions not related to the exhaust would not be evaluated such as evaporative, PCV, and NOx emissions.